COMMONWEALTH OF KENTUCKY

BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

KENTUCKY PUBLIC SERVICE COMMISSION	)	
	)	
VS.	)	CASE NO. 9671
	)	
HARDIN COUNTY WATER DISTRICT NO. 1	)	

O R D E R

The Commission, on its own Motion, hereby orders that:

1. A hearing be and it hereby is scheduled on September 18, 1986, at 1:30 p.m., Eastern Daylight Time, in the Commission's Offices, Frankfort, Kentucky.

2. Hardin County Water District No. 1 ("Hardin Water") shall appear at the hearing and show cause, if any it can, why it should not be subject to the penalties prescribed in KRS 278.990 for failure to comply with the Commission's regulations as set forth on pages 12 through 17 of the attached Commission staff report.

3. The Report on the Collapse of a Hardin County Water District No. 1 Standpipe attached hereto as Appendix A, shall be included as a part of the record in this proceeding. Engineers from the Commission's staff will be available at the hearing to discuss technical details of the Report.

4. Hardin Water shall have until the close of business 2 weeks from the date of this Order to file written comments concerning the contents of Appendix A.

Done at Frankfort, Kentucky, this 29th day of August, 1986.

PUBLIC SERVICE COMMISSION

Chairman

Vice Chairman

Commissioner

ATTEST:

Executive Director

APPENDIX "A"

Commonwealth of Kentucky
Public Service Commission

REPORT ON THE COLLAPSE OF A HARDIN COUNTY WATER DISTRICT #1 STANDPIPE

February 7, 1986

INTRODUCTION

On February 7, 1986, at approximately 6:15 a.m., a 325,000-gallon standpipe collapsed in Hardin County, Kentucky. Hardin County Water District No. 1 ("Hardin Water") owned and operated the water storage tank, which stood at the Northeast corner of the intersection of North Logsdon Parkway and West Elm Road, in Radcliff, Kentucky.

Since Hardin Water falls under the jurisdiction of the Public Service Commission, the Commission investigated the accident. This report provides information pertaining to the tank collapse, and a brief synopsis of pertinent witness accounts. The report also attempts to determine the cause of the accident, and the sequence of events leading to it. Several private agencies are also investigating the standpipe accident. Should these agencies make any substantive information available to the Commission's staff, a supplemental report will be made. Private agencies conducting their own investigations include the Hardin Water's insurer, Marinco, the tank fabricator, Caldwell Tank Company, and the Radcliff Police Department. The engineers

and consultants employed by these agencies in their investigations are given in Appendix A.

Damage From The Accident

The standpipe failure resulted in the destruction of the house at 206 North Logsdon Parkway and damage to several others. In addition, several automobiles were damaged, the storage tank itself was destroyed, and power lines close to the tank were downed. The body of Elsie Carroll, the resident of the house at 206 Logsdon Parkway, was found in the street after the accident by local officials. According to the coroner's report Mrs. Carroll was electrocuted by one of the downed power lines. No other serious injuries occurred. Other than the house that was crushed by the tank, neighboring property was damaged by the water discharged from the tank.

Figure 1 contains an aerial photograph of a part of the accident site, taken by the Radcliff Police. Two of the automobiles damaged by water appear in the upper right hand quadrant of the photograph. The darker of the autos suffered a crushed roof, while the light colored car next to it received damage to the windows facing the tank. When the tank ruptured, thousands of gallons of water flooded property south of the standpipe. Water washed across Elm Road and up against the fronts of several houses not shown in Figure 1, and caused extensive damage. One house had a hole smashed in its front by

the wave of water, while another received roof and facade damage. The wash lifted and moved several cars, including one being driven by Mildred Reed. Mrs. Reed was driving her car past the tank when it fell, and she and the car were lifted and carried across the road. Only slightly injured, Mrs. Reed was able to drive herself to a hospital for examination. Other property damage mainly involved landscaping in the yards surrounding the tank. A fence that had enclosed the base of the tank was also destroyed. Part of its remains appear as the light colored strip running from the tank to the bottom of the photograph. Property damage estimated in excess of $100,000 included five automobiles, three houses, landscaping around the tank, and the tank structure itself.

Collapse Of The Tank

On the morning of February 6, 1986, Anthony Rishkofski witnessed the collapse of the Hardin Water standpipe on Logsdon Parkway. Lack of light limited his vision, however, and he left the scene without realizing the extent of damage that had occurred. He was able, though, to provide police with a sketch of the collapsing tank. In the sketch, the tank appears to bend to the left (north), buckle at about mid-height, and then collapse on itself and fall. His description of the incident was essentially limited to the sketch he provided, and the police in Radcliff were not able to find any other witnesses. Radcliff

police did find people who had observed the tank and its vicinity shortly before the collapse, however. One witness to the scene prior to the accident, Vincent Winters, observed two men in a pickup truck next to the tank about 20 minutes before its failure. One man appeared to come from behind the tower before entering the truck. The identity of the two men has not been determined, and Hardin Water stated that none of its employees was near the tank that morning. Melvin Archer, a local resident, told police he saw water coming from the top of the standpipe the night before the fall. Edward Bailey heard loud pinging sounds coming from the tower prior to 2 a.m., the morning of the accident. Charlie Kerr, jogging by the tower about 20 minutes before its failure, saw water flowing across the road next to it. These observations do not explain what happened at the tank that morning, but they do serve to suggest the overall condition of the structure prior to its failure.

Like the witnesses' accounts, the physical wreckage of the standpipe also serves to suggest the conditions that led to the failure. By working backward from the wreckage, and utilizing the witnesses' accounts, one possible failure sequence of events will be described. Figure 1 shows that the remains of the walls of the standpipe ended up in two large pieces on the ground. The circular plate from the bottom of the tank stayed where it had been, on the concrete foundation shown in the lower left-hand

quadrant of the photo. The piece of the tank wall in the middle left-hand side of the photo came from above the bend that the witness, Mr. Rishkofski, mentioned. The light colored rectangle, in the middle of the photo, is the flattened wall section from below the bend. Sometime during the fall, the upper section of tank doubled back on itself, and folded in two. When it hit the ground, this piece of the structure slid away from the bottom piece, as evidenced by the distance between them.

Though not clearly indicated in Figure 1, the tank began to fall in a northerly direction, then rotated approximately 30 degrees to the west. The anchor bolts around the northern side of the tank base were bent in the same direction as the original direction of fall. The bolts on that side were also bent almost all the way down to the foundation, while those on the southern side were not bent at all. On the ground, the bottom section collapsed almost flat, and ended up approximately four feet from the nearest bolt. Scrape marks on the concrete foundation were evident between the bolts and the bottom of the tank, indicating that the bottom section of the structure was pulled as it neared the end of its fall. Commission staff members also observed that the wreckage of the tank on the north side, at the separation line between the two large pieces, appeared to have been pulled apart. Though not evident in Figure 1, part of the tank wall closest to the foundation buckled and folded into pleats.

The walls of the standpipe had stood on a 1/4-inch thick bottom plate, and were welded to the plate to prevent leakage. This plate was previously mentioned and appears on the circular foundation in the photo. Figure 2, along with providing some detail of the overall structure, includes a cross-sectional view of the wall to bottom plate weld. As seen in the drawing, the tank wall was sealed to the bottom plate with welds on both sides. When the failure occurred, the bottom plate broke from the inside of the interior weld, as the drawing indicates. The circular part of the plate inside the tank stayed on the foundation, while the ring of plate outside the weld went with the rest of the tank. The part of the plate that stayed on the foundation was dished up along its southern edge, and flat along the northern edge. The wreckage of the tank shows that a rupture occurred at the base, and that another occurred midway up the tank.

This report concludes that the initial point of failure in the standpipe was at the base, and that failure resulted from over-pressurization. Calculations by the Commission staff indicate that the pressure in the tank may have been great enough to overcome the weight of the standpipe. As a result of this, the tank would be pushed upward by the pressure, and would try to lift off its base. Anchor bolts surrounded the base of the tank wall, bolting it to the foundation. It appears, however, that the nuts on these bolts may not have been evenly tightened down.

Such a condition was observed by Commission staff at Hardin Water's standpipe on South Wilson Road. The Wilson Road tank was built by the same company as the one that failed, and it is the same basic design, though smaller in diameter and four years older. The consultant for the Radcliff Police Department suggests the bolts were there to prevent overturning or sliding of the tank due to wind forces. There is no indication on the manufacturers drawing as to how tight the tie-down nuts should have been. Without having the nuts tightened down, though, it was possible for the sides of the tank to lift slightly off the foundation.

Under a condition of sufficient internal pressure, the tank structure would begin to lift off its base by deforming the attached bottom plate. The bottom plate would tend to take on a dish-shaped contour by stretching, and bending at the weld connection to the wall of the tank. Evidence of this stretching appeared along the southern edge of the bottom plate, which was dished up off the foundation. Edward Bedell, the metallurgical consultant of the insurer, commented that the metal in the base plate, to which the walls were attached, was brittle. This means the metal in that area would tend to break while undergoing stretching or bending. It appears likely that failure occurred when this deformation took place. When the base ruptured, water

began to eject from that part of the tank, and the weight of the structure shifted to the northern wall.

Loss of water from the standpipe caused the internal pressure of the tank to drop suddenly, thereby allowing the structure's weight to shift back to the walls. The load on the walls would not have been evenly distributed, however, because the tank had been tilted. The load would essentially have rested on the northernmost wall, which was closer to the foundation than the southern wall. Unable to support a load for which it was not designed, the wall became unstable, and buckled at the bottom. It is likely that this is when the witness, Mr. Rishkofski, observed the silo-like structure lean to the left (north). After the north wall buckled at the bottom, the weak vertical seam at mid-height ruptured.

The mid-height rupture in the tank originated at a weld joint in the wall, approximately where the witness saw the structure bend in two. A discussion with Edward Bedell, the metallurgist employed by the insurer, indicated that the failed weld joint contained such a small amount of metal, that it could not have had the strength of a properly made joint. In fact, the joint was not even water-tight, as the photograph in Figure 2A indicates that it was leaking water at least 9 months before the accident. Reference to the contractor's drawings shows that the steel plate used in the tank above, and immediately below, the

mid-height rupture was 1/4" thick. The corresponding welds should have been fabricated by an edge to edge, or butt, weld. Such a joint would require full penetration of the weld, meaning there would be solid weld metal equal to the thickness of the original steel plates at each joint. After the collapse both the insurer's metallurgist and the Commission staff observed that ruptured joint contained far less weld metal than the fabrication drawings called for. Stress calculations by the staff indicate that the poorly made joint may have been only marginally adequate to handle the normal pressure in that area of the tank. When the poorly made joint ruptured, a fairly uniform width of metal ripped open in the side of the tank, and spread horizontally in both directions. This meant there was no longer any support for the top of the tank, which proceeded to collapse onto the overturning lower section of the silo-like structure.

There were two major points of failure observed in the wreckage of the standpipe, the weak weld at mid-height and the brittle metal at the base of the tank. The failures at these points appear to have resulted from over-pressurization of the standpipe. Over-pressurization which was the result of flowing more water into the tank than could exit it under a negligible internal pressure.

Flow of water into the Hardin Water standpipe should have been controlled by the altitude valve located near its base.

Appendix B describes more fully the function and operation of an altitude valve. The altitude valve should have stopped the flow once a certain water level was reached inside the tank. This did not always occur, however, as both the District and residents around the tank have stated. As described in Appendix B uncontrolled excess flow to a standpipe normally overflows through a discharge pipe, and simply drains onto the ground around the tank. In a normal system, the discharge pipe is designed to be big enough to drain the excess influx of water, based on the volume the system pumps can deliver at the overflow level. In this way, the water level is kept below a maximum level and does not flow out the top of the tank. In the case of Hardin Water, the standpipe overflow was adequately sized when the system was originally built in the late 1950's. Years later, however, the system pressure and capacity were increased to serve more customers. As a result, it then became possible to fill the North Logsdon standpipe at a rate greater than the overflow discharge pipe could handle. This means that if the level controlling altitude valve failed to work properly, the water level could continue to rise until it reached the top of the tank. Once there, the water would begin to flow out the standpipe air vent. Once the tank was completely full, if water was still entering it, the pressure inside would begin to increase. The actual rise in pressure would be dictated by the

resistance encountered to discharging the excess flow. Such an increase in pressure would have the direct effect of increasing the stresses in the tank itself.

Flow measurements were done in the vicinity of the failed standpipe to determine approximately what volume of water was available to the tank at the time of the accident. Calculations indicate that a volume of over 1,330 gpm may have been available to the standpipe, at a pressure sufficient to push the liquid past the top of the tank. Calculations were done by the staff, to give an approximate value for the internal tank pressure based on the estimated overflow. The resulting calculated internal pressure was approximately 2.5 psi at the top of the tank. Such a pressure would cause an increase in the tank metal stresses that would tend to pull the seams and joints of the tank apart. The calculated pressure, acting against the top of the tower, could theoretically lift the entire unrestrained tank off its foundation. This in turn would be resisted by the bottom plate, possibly aided by the anchor bolts surrounding the base of the structure. If the nuts on the anchor bolts where not uniformly tightened down, as has been suggested, they would not provide uniform restraint. The tank would rise in whatever direction possible, and create an increasing amount of stress in the bottom plate to wall joint.

Two factors contributed to making this a disastrous situation. There was the weak weld joint in the wall of the tank, which Edward Bedell and David Brown, metallurgists for the insurer, verbally confirmed as the point of origin of failure in the wall. More important than this, however, was the inability of the anchor bolts to prevent the uplift of the tank walls. The failure of the tank's north wall appeared to result from its taking a load for which it was not designed. The transfer of such a destabilizing load onto that portion of the tank wall, probably occurred because the silo-like structure was tilted toward that wall. Tilting of the structure would have resulted when the bottom plate of the tank began to rise, due to internal pressure and inadequate restraint by the tank's anchor bolts. Primary failure probably occurred when the brittle metal at the base of the tank broke, while being bent into the dish-shape mentioned earlier in this report. Once the bottom plate began to separate from the tank walls, the north wall proceeded to buckle, and collapse of the tank followed.

Violations

At the time of the standpipe failure, Hardin County Water District No. 1 was in violation of several provisions of 807 KAR 5:006, the General Rules of the Public Service Commission. Specifically, Hardin Water was in violation of:

Section 24. Reporting of Accidents

Hardin Water has yet to report the standpipe accident to the Public Service Commission. Since death and substantial property damage occurred, the utility is required to notify the Commission promptly by telephone or telegraph. A written report to the Commission is required within 7 days of the accident. Hardin Water did not comply with these requirements.

Section 23. Inspection of System

This section of the law is intended to promote safe and adequate operation of utilities by requiring system inspections. Systematic inspections should reveal some of the more obvious system problems, giving the utility a chance to correct them before they cause extensive damage or injury. For this reason, Paragraph (1) requires adoption of an inspection procedure, and a filing of this procedure with the Public Service Commission. Paragraph (5) sets specific guidelines for the time interval between inspections of various components in the systems, but does not limit

inspection responsibility to those specific components. Further, the regulation requires the utility to keep records on the inspections, and corrective actions resulting therefrom.

Based on conversations Commission staff members and the Radcliff Police Department have had with Hardin Water personnel, there appears to be no evidence that Hardin Water ever conducted an adequate safety inspection of its system. Along with violating the overall intent of Section 23, the utility violates specific parts of the regulations by not having an inspection procedure on file with the Commission. Further, the utility does not appear to conduct any systematic checks of its facilities, and it keeps no records of inspections or repairs to system deficiencies discovered.

A primary problem at the time of the accident may have been the malfunctioning of the standpipe altitude valve. Inspection of the valves used to control flow into a

standpipe is covered by part (5) g. of Section 23. There is evidence the valve at the North Logsdon standpipe malfunctioned repeatedly in the past, though there is no record of any inspection or corrective action made by Hardin Water. According to the Hardin Water Manager at the time of the accident, repairmen would attend to the valve whenever the standpipe was reported to be overflowing. The tank itself does not appear to have been inspected adequately by Hardin Water, even though it was rusted and leaking water. As required by the General Rules the valves controlling flow to the standpipe should have been inspected, and the tank structure itself should have been given attention once the leak condition was pointed out to the utility.

Section 22. Safety Program

Based on observations of Commission staff members, Hardin Water has not established a safety program for its employees. Such a program is a requirement of the General Rules.

Section 19. Location of Records

Under the regulations Hardin Water should keep records pertaining to its safety inspections. Records should also be kept regarding the utility's response to reports of potentially hazardous conditions. The General Rules require that these records be kept at the central office of the utility, and be available for review by Public Service Commission personnel. The utility does not meet these requirements.

Section 18. System Maps and Records

This section of the regulations require utilities to maintain up-to-date maps or records of its system. Such maps would include the general district served, the location and size of the utility's water lines, and the location and layout of its plants and main items, such as standpipes. Hardin Water fails to comply with this section of the regulations. To date, the exact arrangement of piping around the collapsed standpipe is not known. The lack of such knowledge has hampered the Commission's

investigation of the standpipe accident. Further, this lack of knowledge about its own system caused confusion among district personnel who sought to isolate the standpipe site after the accident.

Recommendations

Having previously discussed the various points of Hardin Water's noncompliance with 807 KAR the Commission staff recommends that Hardin Water be directed to immediately correct its noncompliance and that a Show Cause proceeding be initiated against the utility. At the proceeding, Hardin Water should be ready to explain why it is out of compliance with the pertinent sections of 807 KAR 5:006. That utility should be ordered to show cause why the Commission should not assess penalties for the stated violations.

The Commission staff further recommends that Hardin Water be directed to have a thorough and comprehensive engineering hydraulic analysis made of its system. The Commission staff believes such an analysis will make the utility better aware of both existing and potential operational problems with its water system. A report of the analysis should be made and submitted to the Commission for its review.

Finally, the Commission staff recommends that Hardin Water remove its Wilson Road standpipe from service. Initial

investigation by the staff indicates that the standpipe serves no necessary hydraulic function. The previously suggested hydraulic analysis should demonstrate the purpose and effect of the Wilson Road standpipe. Of critical concern is the fact that the Wilson Road tank was designed and constructed by the same firm that erected the failed Logsdon Parkway tank. The Wilson Road tank is the same height as the one that fell, smaller in diameter, and approximately four years older. It has the same overflow elevation as the failed unit, and has itself overflowed in the past. In fact, the Hardin Water manager told one staff member that it overflowed two days after the other tank fell. The Wilson Road tank has not, to anyone's knowledge, received any more attention than the collasped Logsdon Parkway tank. Rust, which may indicate deterioration of the walls, was evident on the exterior of the tank earlier this year. If Hardin Water can satisfactorily demonstrate the hydraulic necessity of the tank, it should have the tank completely evaluated for structural integrity and safety before placing it back in service.

Respectfully submitted,
April 30, 1986

Edwin R. Klein
Public Service Engineer Chief

Reviewed by

Eddie B. Smith
Public Service Engineer Manager

Appendix A

Marinco, the San Antonio based insurer of Hardin Water, retained a Louisville based property damage adjustor, and an Atlanta based liability adjustor. Adjustco, the Louisville firm, retained Metallurgical Services Company and Advanced Process Systems, Inc., to investigate the engineering aspects of the accident. Caronia Corporation, of Atlanta, employed Law Engineering and Testing Company, and GRW Engineering, for their investigation. The Radcliff Police Department hired Michael Cassaro, a Civil Engineer and a University of Louisville professor, to investigate the accident, and a Louisville Engineering firm, Derrick Engineering, Inc., to examine the standpipe valve pit. Caldwell Tank Company of Louisville, built the standpipe, and will probably address the accident in some manner of report. To date only Michael Cassaro's report has been obtained by the Commission staff.

Appendix B

Standpipe And Valve Pit Description

The collapsed standpipe, on North Logsdon Parkway, was a 325,000-gallon water storage reservoir. Two photographs of the standpipe appear in Figure 1A and Figure 2A. Constructed in 1959 for Hardin Water, the tank was of welded construction and was to meet the criteria of the American Water Works Association Standard Specifications 7H-1-1948. This specification addresses the design and fabrication of welded steel tanks, standpipes, and reservoirs for water storage. The standpipe base was 22 feet in diameter, and the straight wall height was approximately 115 feet. Including the roof, the overall tank height to the outlet of the air vent was 120 feet. Prior to failure, the standpipe resembled a silo with a height of approximately five times its width. The standpipe walls sat on a 1/4-inch thick steel plate, which formed the bottom of the tank. The walls were welded to this plate to form a seal against leakage. Underneath the standpipe a concrete foundation supported the entire structure. Water fed into, and out of, the tank through a 10-inch pipe in its bottom.

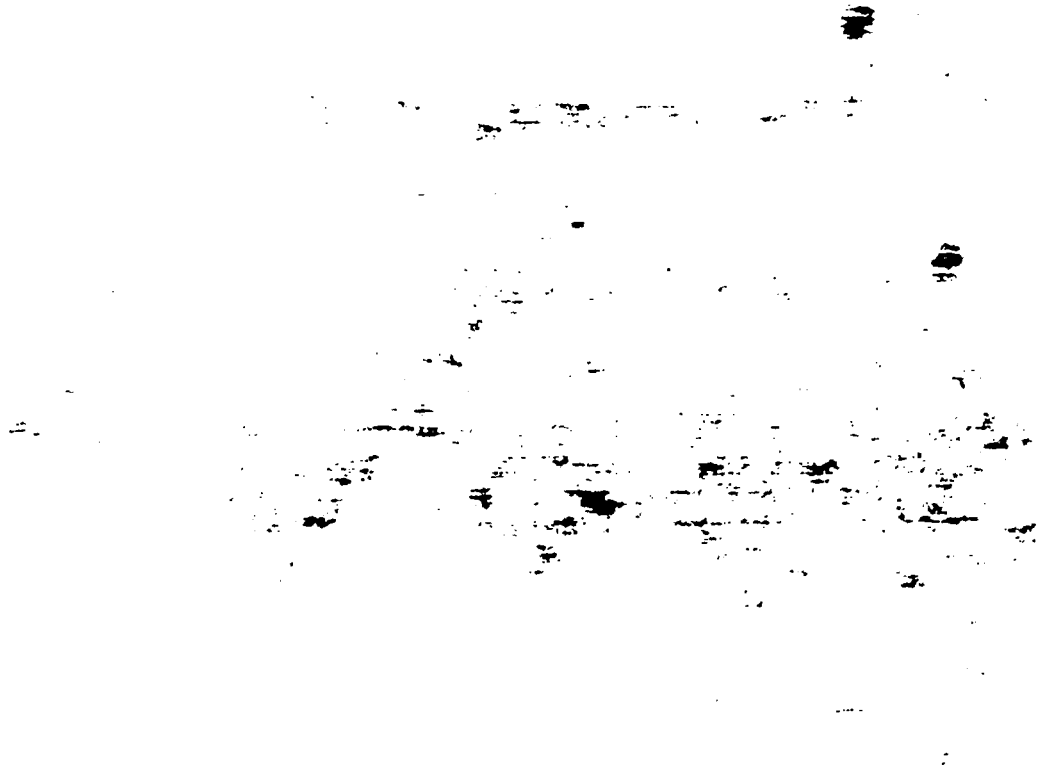
The tank was constructed of steel plate ranging in thickness from 1/4" - 1/2", and was built in 1959 by Caldwell Tank Company of Louisville, Kentucky. The District's consulting engineers for the 1959 construction were Synder, McLellan and Associates of

Hillsboro, Indiana. The general contractor for the 1959 construction was Coleman Trainor & Company of Huntington, West Virginia.

Based on information provided by the District's personnel, the standpipe on North Logsdon Parkway received water from a 6-inch main running beneath Logsdon Parkway, and a 10-inch main under West Elm Road. These lines came together, and then flowed water to a valve pit next to the tank through a common 10-inch line. The purpose of the valve pit was to allow water to flow into the standpipe when the tank level dropped below a certain point. Water would then fill the tank till a pre-set level was obtained, and then stop. Then, or when, the system pressure dropped, the standpipe would empty back into the system through the piping in the valve pit.

To accomplish this, the valve pit contained three parallel lines, one line contained a manually operated valve that allowed the District to essentially by-pass the other two lines in the pit. This valve was normally closed. The line next to this contains a check valve, which would check (i.e. stop) the flow of water into the tank. When the system pressure would drop, this valve would then allow water to flow out of the tank. The third line contains an altitude valve, which would control the flow of water into the tank. As a control valve, the function of the altitude valve was to prevent the water level in the tank from

rising above a certain point, and to allow water to enter the tank when the level dropped below this point. If the valve malfunctioned, it could either allow water to continue filling the tank after the high level was reached, or it might not let water enter the tank at all. Finally, the valve pit contains a main shut-off valve which is operated manually, and can completely stop flow into, or out of the tank.



Appendix C

Maintenance Background

Detailed records of the maintenance work performed on the equipment at Hardin County do not exist. Information does exist however to verify that the Logsdon standpipe was painted during 1975-76. Maintenance such as this does not occur on a strictly regular basis. Free-lance contractors compete for the business of utilities like Hardin County by visiting the facilities and doing their own evaluation of needed repairs. Apparently, to get a particular job, this type of contractor must convince the utility a repair is needed. One such salesman, Marvin Noe of Leary Construction, visited Hardin County in May 1985, and presented Hardin Water with photographs showing rust damage on the outside of the Logsdon standpipe. In one photo, shown in Figure 2A, rust appears to start at a point about midway up the height of the tank and then fans out toward the base. Another photo reportedly showed leakage at the base of the tank. No action was taken by the district, and the photographs given to the District were thrown away. The contractor's inspection of this tank, and the other Hardin Water tanks in Radcliff, did not include a structural evaluation.

Based on discussions with District personnel, the standpipes in the District received only cursory attention. Groundskeeping constituted the main maintenance activity. Valve pit maintenance

was done on a strictly "as needed" basis. If a water tank overflowed, then the valves in its pit were serviced, otherwise they were left alone. The employee of the District who did the majority of work on the valves, Jr. Dolly, died in a District related accident last year, apparently leaving no maintenance records behind. According to Marvin Logsdon, Hardin Water Manager at the time of the accident, Jr. Dolly reset the Logsdon altitude valve whenever the tank overflowed, which it reportedly did often. As mentioned previously, there are several valves in each valve pit. Whatever kinds of maintenance or repair work Mr. Dolly did on the Logsdon standpipe valves was not documented. There is no recorded operational history on the valves, though they are known to have had operational problems.

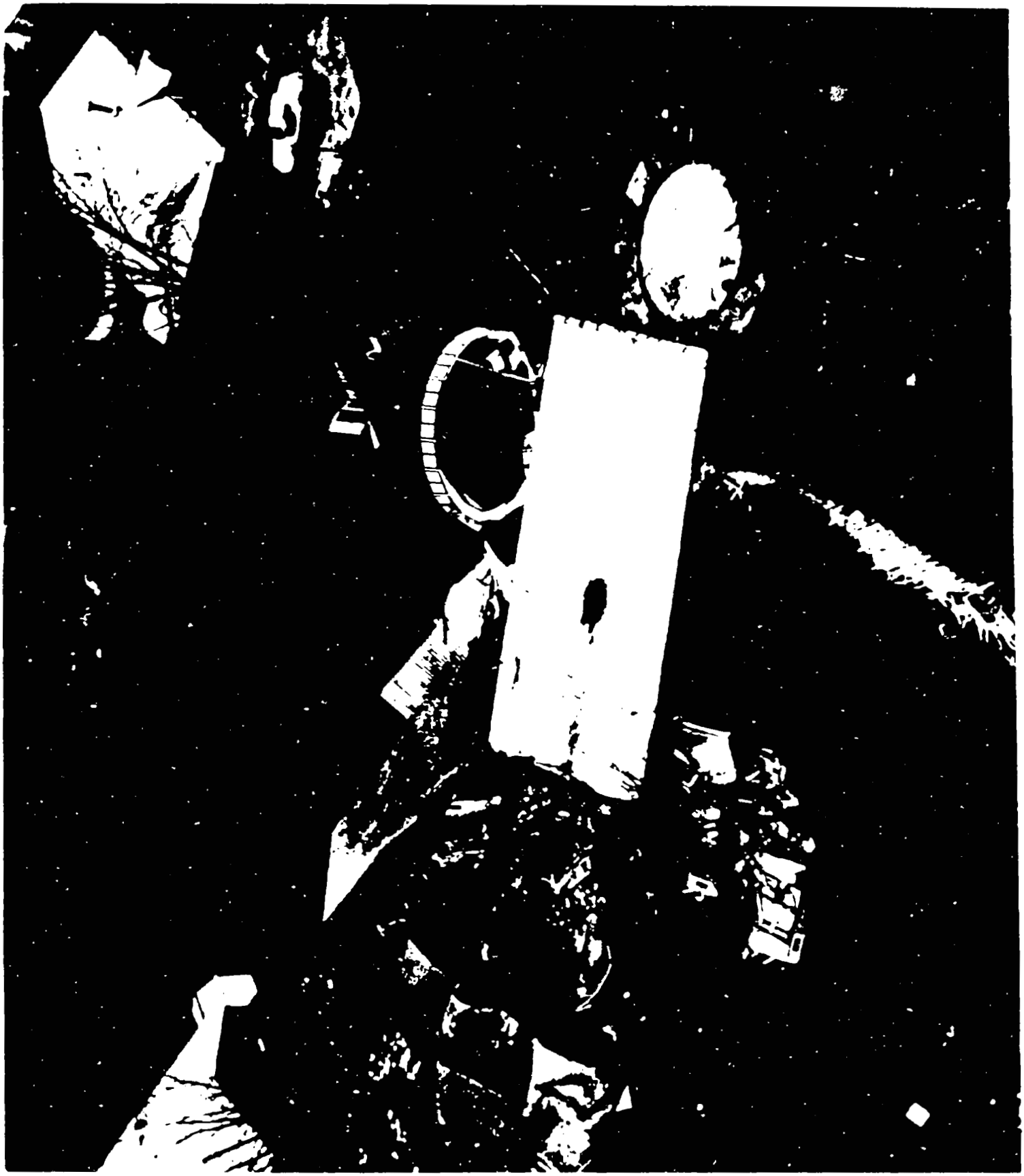


Figure 1 Aerial View of the North Logsdon Accident Site
(Photograph A-5, Radcliff Police Department, 1986)

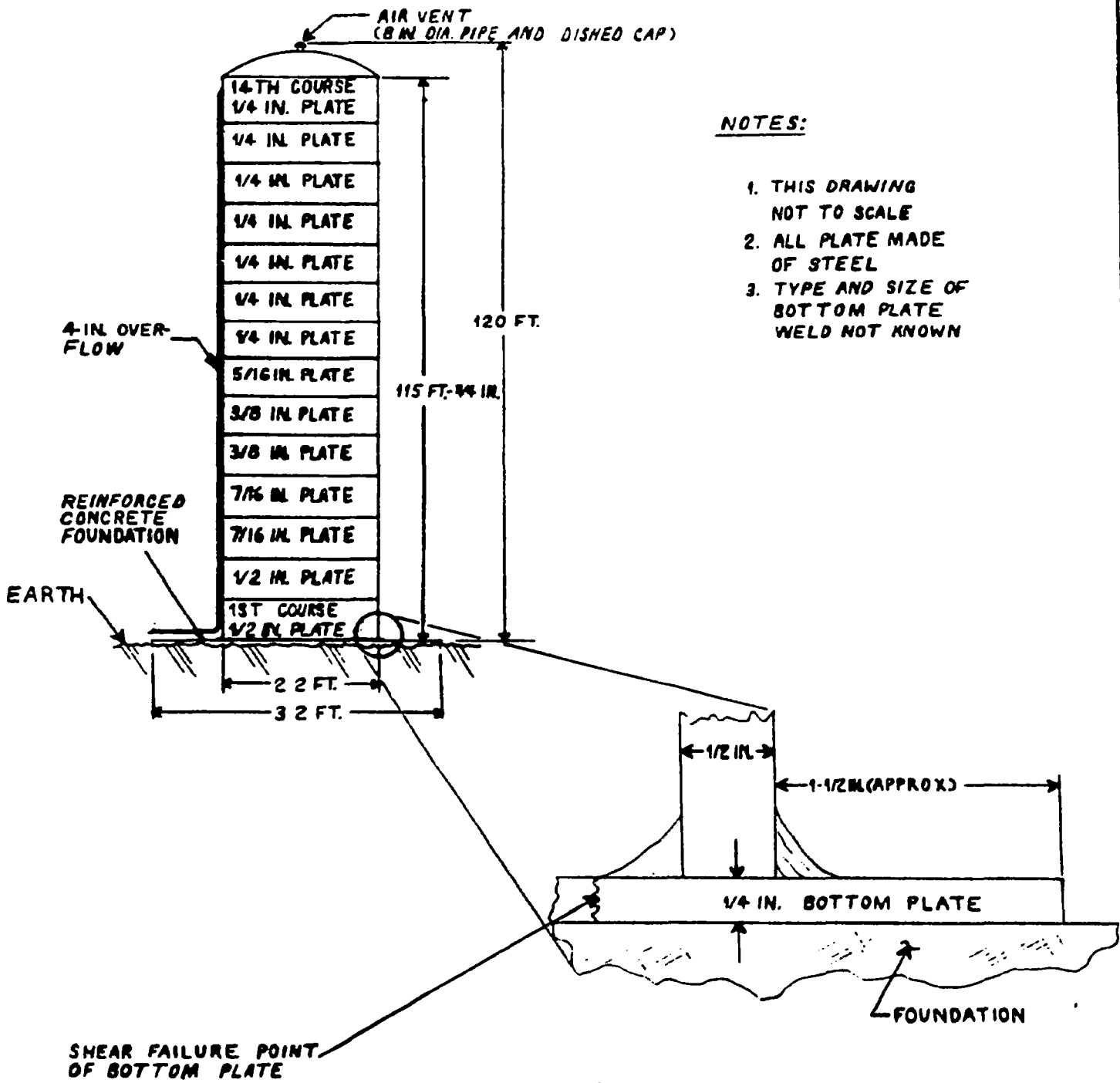


FIGURE 2. STANDPIPE CONSTRUCTION DETAILS

Figure 1A Hardin Water Standpipe On North Logsdon Parkway
(Reproduction of photographs taken by Marvin Noe, Leary Const., May 1985)

Figure 2A Rust On The Outside Of The Standpipe On North Logsdon Parkway
(Reproduction of photographs taken by Marvin Noe, Leary Const., May 1985)